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In this Issue: OCEAN TURBULENCE
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Earth's oceans form a complex web of physical processes. The actions of the oceans, which cover over 70% of its surface, regulate the planet's climate. The top five meters of the ocean can store as much heat as the entire atmosphere, and contain fifty times more carbon. They transport heat from the equator towards the poles, moderating the otherwise great extremes of temperature which would exist on our planet. In the Northern Hemisphere, oceans warm continuously from March to September and cool for the rest of the year. The quantity of heat stored and released is approximately 30% of that received from the Sun.

Oceans also serve the important function of absorbing approximately 50% of the CO_2 produced by humanity. They are able to absorb a great deal of the heat produced by the "enhanced" greenhouse effect that ensues from the CO_2 emissions. By so doing, they delay climate changes.

These complex physical processes must be realistically reproduced by any ocean model that is employed to study future climate changes. Processes which determine the state of the ocean occur over scales ranging from the very large (thousands of kilometers) down to the very small (centimeters). Due to the limitations of present computers, only those processes which operate over fairly large scales (100 km) can be simulated explicitly.

Processes occurring on smaller scales must be described by "models" that represent the effects of these smaller scales in terms of what occurs at the larger scales. In order for the ocean model to reproduce the behavior of the real ocean these models must realistically capture the ocean physics. It is clear that if a model mimics these physical processes by using parameters which need to be adjusted in order to reproduce today's climate, it can hardly be relied upon to predict future scenarios that may differ substantially from today's situation. It is thus very important to generate a model in which the turbulent transport of heat, salt and momentum are not only as free as possible from adjustable, ad hoc parameters, but also tested in contexts different than the ocean case, so as to guarantee a level of generality for the model.

In a series of papers published in The Physics of Fluids, GISS physicists Vittorio M. Canuto and Mikhail S. Dubovikov developed a new model to treat turbulent transport processes. The model, which was successfully tested on a large variety of turbulent flows, has now been applied to study ocean turbulence. In a series of five papers submitted to Journal of Physical Oceanography, they and GISS scientists Armando M. Howard and Ye Cheng developed and successfully tested a new formulation for the turbulent diffusion of momentum, heat and salinity. It must be noted that, contrary to all previous treatments, the model for diffusivity due to salinity gradients was derived from basic physical principles. Two independent models were actually derived and shown to yield very similar results. An overall better agreement with the oceanic data was obtained. The new horizontal diffusivities are presently being tested in collaboration with MIT scientists.

This is the first time that the vertical and horizontal turbulent transports processes in the ocean have been derived from first principles and shown to reproduce the data reasonably well. This degree of generality is required to give confidence and reliability to the ocean models when applied to describe future physical scenarios that may differ substantially from today's ocean.

Reference: Canuto, V.M., A. Howard, Y. Cheng, and M.S. Dubovikov, 1999. Ocean turbulence I: One-point closure model: Momentum and heat vertical diffusivities. J. Phys. Ocean, submitted.

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